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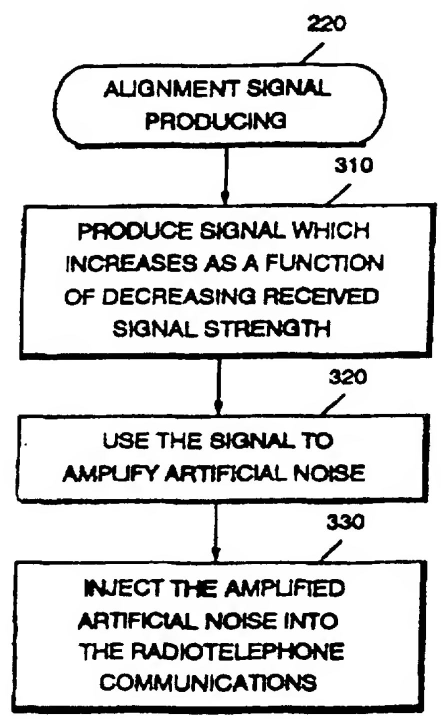
(54) Title: METHOD AND APPARATUS FOR ANTENNA REALIGNMENT IN A MOBILE RADIOTELEPHONE USING AN INJECTED AUDIO SIGNAL

(57) Abstract

A mobile radiotelephone injects an audible alignment signal which is a function of the orientation of the radiotelephone antenna, into the audible radiotelephone communications. The audible alignment signal prompts the radiotelephone user to reorient the radiotelephone antenna for improved alignment with the source of radiotelephone communications. The audible alignment signal is preferably a function of the received signal strength of the radiotelephone communications. The audible alignment signal is preferably artificial noise which is injected in the radiotelephone loudspeaker along with the radiotelephone communications signal, to thereby restore subjective graceful degradation behavior to the received radiotelephone communications. Artificial noise injection is preferably used with coded digital radiotelephone systems which do not audibly degrade until a threshold is reached, below which communications are suppressed. Artificial noise injection may also be used with variable power base stations.



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METHOD AND APPARATUS FOR ANTENNA REALIGNMENT IN A MOBILE RADIOTELEPHONE USING AN INJECTED AUDIO SIGNAL

Field of the Invention

This invention relates to communications systems, and more particularly to mobile radiotelephone communications systems which communicate with terrestrial base stations or orbiting satellites.

Background of the Invention

Radio communications systems are increasingly being used for wireless mobile communications. Radio communications systems use mobile radiotelephones which communicate with terrestrial base stations or orbiting satellites. An example of a mobile radiotelephone communications system is a cellular telephone system. Cellular telephone systems are wide area communications networks which utilize a frequency reuse pattern. The design and operation of an analog cellular telephone system is described in an article entitled *"Advanced Mobile Phone Service"* by Blecher, IEEE Transactions on Vehicular Technology, Vol. VT29, No. 2, May 1980, pp. 238-244. The analog mobile cellular system is also referred to as the "AMPS" system.

Recently, digital cellular telephone systems have also been proposed and implemented using a Time-Division Multiple Access (TDMA) architecture. Standards have also been set by the Electronics Industries Association (EIA) and the Telecommunications Industries Association (TIA) for an American Digital Cellular (ADC) architecture which is a dual mode analog and digital system following EIA/TIA document IS-54B. Telephones which implement the IS-54B dual mode architecture are presently being marketed by the

assignee of the present invention. Different standards have been promulgated for digital cellular phone systems in Europe. The European digital cellular system, also referred to as GSM, also uses a TDMA architecture.

As is well known to those having skill in the art, mobile radiotelephones include an antenna and a transceiver for receiving radiotelephone communications via the mobile radiotelephone antenna. In a vehicular mobile radiotelephone, the antenna is typically mounted on the vehicle body. In a handportable mobile radiotelephone, the antenna typically projects from the housing of the handportable radiotelephone. Proper orientation of the antenna relative to the radiotelephone communications signal is important for clear reception without distortion or dropouts. As is well known, often a slight reorientation of the antenna produces a marked improvement in radiotelephone reception. For example, handportable phones suffer a loss of signal strength when the transmission is being received from the other side of the user's head. Head blockage can cause 6dB loss of signal.

Because antenna orientation is so important in a mobile radiotelephone, many mobile radiotelephones provide a display of the received signal strength of the radiotelephone communications signal, which can prompt the user to reorient the antenna. Moreover, the quality of the received signal in an analog or uncoded digital mobile radiotelephone system tends to degrade gradually with increasing misalignment of the antenna. Thus, the noise level tends to gradually increase, which can prompt the user to reorient the antenna, by moving the vehicle or the handportable radiotelephone, in order to reduce this noise.

It is now common to employ digital speech coding and/or digital error correction coding in radio communications systems, in order to improve

communications efficiency. This digital coding permits communications at good quality down to very low signal-to-noise ratios as low as 2dB or less, with very sharp cutoff below this threshold. Thus, the graceful degradation of analog FM or uncoded systems is lost and is replaced with an abrupt cutoff below a threshold. In such digital coded radio communications systems, poor orientation can cause the signal strength to fall below the threshold so that communications abruptly cease. The decrease in signal strength is not accompanied by an increase in noise level which could prompt antenna reorientation.

Summary of the Invention

It is therefore an object of the present invention to provide systems and methods for orienting mobile radiotelephone antennas relative to received mobile radiotelephone communications.

It is another object of the invention to provide methods and systems for orienting antennas in digital mobile radiotelephones which employ coding techniques and thus produce a threshold below which the signal is cut off.

These and other objects are provided according to the present invention by a mobile radiotelephone which injects an audible alignment signal, which is a function of the orientation of the radiotelephone antenna, into the audible radiotelephone communications. The audible alignment signal prompts the radiotelephone user to reorient the radiotelephone antenna for improved alignment relative to the source of the radiotelephone communications.

In particular, the received radiotelephone communications have a received signal strength which is a function of the location of the radiotelephone antenna. According to the invention, an audible alignment signal, which is a function of the received

signal strength of the radiotelephone communications, is injected into the audible radiotelephone communications. The audible alignment signal can be a direct function of received signal strength, or it can be a function of another parameter which indirectly depends on signal strength, such as distortion or noise level. The audible alignment signal is preferably artificial noise which is injected into the radiotelephone loudspeaker along with the radiotelephone communications signal, and thereby restores subjective graceful degradation behavior to the received radiotelephone communications. By artificially restoring subjective graceful degradation behavior, the present invention prompts the user to reorient the radiotelephone antenna for receiving radiotelephone communications.

A mobile radiotelephone according to the present invention includes means for receiving radiotelephone communications, including an antenna and a radio transceiver. Signal strength indicating means is responsive to the receiving means for producing a signal strength indication which is a function of the signal strength of the received radiotelephone communications. As described above, the signal strength indication may be a direct or indirect function of signal strength. Acoustic transducing means, which typically includes one or more loudspeakers or earspeakers and which may include voice codecs and other circuitry, is responsive to the receiving means and to the signal strength indicating means to produce an audible signal which combines the received radiotelephone communications and the signal strength indication, such that an audible signal strength indication is provided along with audible radiotelephone communications.

The present invention is particularly useful in digital coded mobile radiotelephones or other mobile

radiotelephone systems wherein the receiving means is an abrupt cutoff receiving means, which produces an audible radiotelephone communications signal when a received signal strength of a radiotelephone communications signal is above a threshold and which suppresses or cuts off the audible radiotelephone communications signal when the received signal strength is below the threshold. In such a radiotelephone, the signal strength indicating means produces a warning signal which is a function of the received strength of the radiotelephone communications signal to indicate that the received signal strength is approaching the threshold.

The signal strength indicating means preferably comprises means for producing artificial noise which increases as a function of the decrease in the received signal strength of the radiotelephone communications signal, to thereby indicate that the received signal strength is degrading or approaching the threshold. Preferably, the artificial noise increases as a function of the decrease of the received signal strength from a received signal strength which is above the threshold to a received signal strength which is below the threshold, to thereby indicate that the received signal strength is approaching the threshold and has passed through the threshold. However, audible indications that increase in intensity with increase in signal strength may also be used. Thus, even after the radiotelephone communications signal has been suppressed, the artificial noise level can still prompt the user as to antenna reorientation which will restore communications.

The artificial noise can be any signal which is different from the received radiotelephone communications and which changes as a function of antenna orientation. For example, the artificial noise may be broadband white noise or pink noise, a single

sinusoidal frequency or multiple sinusoidal frequencies which change in amplitude or frequency as the signal strength decreases. Alternatively, the artificial noise may be a periodic signal, such as a click or chirp, the repetition periodicity of which changes as a function of changes in the received signal strength of the radiotelephone communications signal, to indicate that the received signal strength is degrading or approaching the threshold. This changing periodicity signal may sound like a radio tuning indication. The artificial noise may also be a synthesized voice message such as the audible word "move", which increases in amplitude or frequency as the received signal strength decreases.

The present invention is also particularly useful with mobile radiotelephone systems which use automatic power control at the transmitter (terrestrial base station or satellite). These transmit power control systems cause the transmitter to increase its power in response to an indication from the mobile radiotelephone that the mobile radiotelephone is receiving a low signal strength. This automatic power control system provides an even sharper threshold because it prevents signal degradation for slow decreases in received signal strength which the automatic power control system can track, until no more power can be provided.

According to the invention, a transmit power indicating signal is transmitted by the transmitter along with radiotelephone communications. The audible alignment signal is also made responsive to the transmit power indicating signal which is received by the radiotelephone, to thereby produce a signal strength indication which is a function of the signal strength of the received radiotelephone communications and of the transmit power of the received radiotelephone communications. Thus, for example, as

the transmit power increases, the amount of artificial noise which is injected also increases, to thereby prompt reorientation of the antenna so that reduced transmit power levels can be used.

The present invention prompts a user to reorient the radiotelephone antenna for better reception by injecting an audible artificial noise signal into the audible radiotelephone communications. The user can be prompted to reorient the antenna before audibly degraded communications is reached. Improved mobile radiotelephone communications are thereby provided.

Brief Description of the Drawings

Figure 1 is a block diagram of a mobile radiotelephone wherein the present invention may be used.

Figure 2 is a block diagram of a receive Digital Signal Processor (DSP) which produces an alignment signal according to the present invention.

Figure 3 illustrates operations for producing a first alignment signal according to the present invention.

Figure 4 illustrates operations for producing a second alignment signal according to the present invention.

Figure 5 is a block diagram of received signal processing according to a second embodiment of the invention.

Figure 6 is a block diagram of a demodulator according to the second embodiment of the invention.

Detailed Description of Preferred Embodiments

The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. This invention may,

however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout.

Referring now to Figure 1, a functional block diagram of a mobile radiotelephone wherein the present invention may be used, is shown. Mobile radiotelephone **100** may be a vehicular mobile radiotelephone but is preferably a handportable mobile radiotelephone. Mobile radiotelephone **100** typically receives radiotelephone communications **150** from a terrestrial base station **155** or an orbiting satellite (not shown). Figure 1 is a simplified representation of a dual-mode cellular radiotelephone which is described in greater detail in U.S. Patent Application Serial No. 07/967,027, entitled *"Multi-Mode Signal Processing"* by coinventor Paul W. Dent and Björn Ekelund and assigned to the parent company of the present assignee, the disclosure of which is hereby incorporated herein by reference.

Briefly, antenna **145**, radio transceiver **140** and receive Digital Signal Processor (DSP) **125** function as means for receiving radiotelephone communications **150**. Receive DSP **125** processes the signal which is received from the radio transceiver **140** via DSP interface **135** and produces a digital audio signal which can be applied to voice codec **115** for transmission over an acoustic transducer such as a loudspeaker **110**. Transmit DSP **120** receives a digitized voice signal from microphone **105** via voice codec **115** and provides this signal to DSP interface **135** for transmission by radio transceiver **140** and antenna **145**. Microcontroller **130** controls some or all of the components of the mobile radiotelephone **100**. The design of mobile

radiotelephone **100** is well known to those having skill in the art and need not be described further herein.

The present invention is preferably embodied, in part, as a stored program which executes on the receive DSP **125**, which may be, for example, a Texas Instruments C53 Digital Signal Processor. However, the present invention may also be embodied, in part, as a stored program executing on microcontroller **130** or on another processor. Alternatively, custom logic designs, or combinations of software and hardware may be used. In an analog radiotelephone system, analog components may be used.

Referring now to Figure 2, a block diagram of receive DSP **125** of Figure 1 which is configured according to the present invention, will now be described. As shown in Figure 2, receive DSP **125** includes communications signal producing means **210** which produces a digital received radio communications (voice) signal **250** from the radiotelephone communications which is received from DSP interface **135**. Communications signal **250** is applied to voice codec **115** for conversion to an analog signal, which is supplied to loudspeaker **110** to produce audible radiotelephone communications. Communications signal processing means **210** may include digital speech decoding and error correction functions to produce an abrupt cutoff receiver using techniques well known to those having skill in the art. In such a coded digital system, an audible radiotelephone communications signal is produced when a received signal strength of a radiotelephone communication is above a first threshold, and the audible radiotelephone communications signal is suppressed when the received signal strength is below a second threshold.

Still referring to Figure 2, receive DSP **125** also includes alignment signal producing means **220**. Alignment signal producing means **220** may receive an

indication of received signal to noise ratio from DSP interface **135**. As will be understood by those having skill in the art, radio transceiver **140** may produce a received signal strength indication signal. Alternatively, receive DSP **125** or microcontroller **130** may generate a received signal strength indication signal from the received radio communications. The generation of a received signal strength signal is well known to those having skill in the art and need not be described further. Alignment signal producing means **220** produces an alignment or warning signal **240** which is a function of the received signal strength of the radiotelephone communications signal.

The alignment signal **240** is injected into the audible radio communications signal by combining the digital received radio communications signal **250** and the alignment signal **240** at summer **230**. Summer **230** produces a combined signal **260** which is provided to voice codec **115** for conversion to an analog signal and broadcast over loudspeaker **110**. It will be understood that the radio communications signal **250** and alignment signal **240** need not be combined, but rather may be separately provided to one or more loudspeakers or earpieces **110**, as long as an audible alignment signal is injected into the audible radiotelephone communications. In the embodiment of Figure 2, alignment signal producing means **220** and summer **260** form injection means for injecting an audible alignment signal which is a function of the orientation of the radiotelephone antenna, into the audible radiotelephone communications. Acoustic transducing means, such as loudspeaker **110** and voice codec **115** are responsive to receive digital processor **125** to produce an audible signal which combines the received radiotelephone communications signals **250** and the alignment signal **240**, such that an audible signal strength indication is

injected into the audible radiotelephone communications.

Referring now to Figure 3, operations for producing a first embodiment of an alignment signal (Block **220** of Figure 2) will now be described. In particular, at Block **310**, a signal is produced which increases as a function of decreasing received signal strength. At Block **320**, an artificial noise signal is generated and is scaled or amplified by the signal which is produced at Block **310**. Accordingly, artificial noise is produced whose amplitude increases as a function of decreasing received signal strength, thus providing an artificial indication of gradual degradation of signal strength. At Block **330**, the amplified artificial noise is injected into the audible radiotelephone communications.

It will be understood by those having skill in the art that the artificial noise signal can be white noise, pink noise or any other kind of broadband noise, or may be single or multiple frequency noise such as sinusoidal noise or multiple sinusoids whose amplitudes increase or decrease with a reduction of received signal strength. Preferably, an audible indication which increases with signal strength is chosen to have "pleasing" characteristics, such as a musical major chord, while an audible indication that increases with worsening signal would be given "non-pleasing" characteristics, such as white noise or a discord. In a digital system which provides an abrupt threshold below which communications cease, the artificial noise signal preferably becomes audible above the threshold and becomes stronger as the received signal strength passes through the threshold and drops to below the threshold, to prompt the user to reorient the radiotelephone antenna to restore communications.

Referring now to Figure 4, a second embodiment **220'** of alignment signal producing **220** of Figure 2 will now be described. At Block **410**, a first signal is produced which increases as a function of decreasing received signal strength, as was already described in connection with Block **310**. At Block **420**, a second signal is produced which increases as a function of increasing transmit power.

It will be understood by those having skill in the art that in mobile radiotelephone systems which use automatic transmit power control, the base station **155** (Figure 1) or satellite increases its transmit power in response to an indication that the mobile radiotelephone **100** is receiving a less than desired signal strength, and decreases its transmit power in response to an indication that the mobile radiotelephone **100** is receiving a greater than desired signal strength. According to the invention, an indication of the base station or satellite transmit power is provided in downlink transmissions of radiotelephone communications **150** which are received by the mobile phone. Accordingly, at Block **220**, a second signal is produced which increases as a function of increasing transmit power from the network. The audible indication is thus controlled by feedback from the network prompting the user to reorient his antenna in order to improve either up- or downlink.

Continuing with the description of Figure 4, at Block **430**, the first and second signals are combined to produce a third signal which varies as a function of the first and second signals. For example, the third signal will increase as a function of decreasing received signal strength but will also increase as a function of increasing transmit power. Accordingly, when transmit power is increased, the alignment signal will increase to prompt the user to reorient the antenna so that the transmitter can produce lower

transmit power. At Block **440**, the alignment signal is produced. In Block **440**, the artificial noise signal is a periodic signal such as a sine wave or clicks, the frequency of which is varied based on the value of the third signal. Thus, this variable frequency artificial noise signal provides a tuning indication wherein, for example, higher frequency indicates lower signal strength and higher transmit power. At Block **450**, the artificial noise is injected into the radiotelephone communications.

Accordingly, the present invention produces an audible alignment signal which is a function of the orientation of the radiotelephone antenna (and also possibly the transmit power of the base station or satellite) which indicates alignment or misalignment of the radiotelephone antenna for reception of the radiotelephone communications. The user is then prompted to reorient the antenna so that the alignment signal decreases. The invention provides a graceful degradation indication which can be used in analog systems to provide a graceful degradation indicator before actual system noise begins to intrude, and can be used in digital systems which employ coding to indicate that a cutoff threshold is about to be approached, or has been passed. The user is prompted to reorient the antenna and restore a high quality signal.

Referring now to Figure 5, a second embodiment of the present invention is illustrated. Figure 5 illustrates a different partitioning of the block diagram of receive signal processing in either a radiotelephone or a transmitter (terrestrial base station or satellite). Figure 5 is a functional partitioning corresponding to Figure 1 which is a hardware partitioning.

Signals plus noise and interference are received at antenna **145** and downconverted by radio

transceiver **140** and digitized to obtain a signal representation suitable for digital signal processing. Receive DSP **125** processes the converted received signal to perform demodulation and error-correction decoding functions **500** to obtain digital symbols representing coded speech. The coded speech is further decoded in DSP **125** and converted to analog speech by CODEC **115**, which functions are designated as Block **510** in Figure 5. Block **500** also decodes command messages and passes them to control processor **130**. Block **500** also produces a signal quality indication representing the probability that decoded bits passed to speech decoding **510** are error free.

Speech decoder **510** may include the ability to ignore bits indicated to be unreliable and to output default speech sounds or otherwise conceal the effect of erroneous bits by a process known as "speech parameter interpolation". Error concealment may include outputting "comfort noise" during periods of unreliable signal. The comfort noise avoids abruptly cutting off all acoustic output which gives the undesirable impression of "chopped" speech. According to an embodiment of the present invention, the demodulation and decoding function **500** can additionally output a signal representing the radio noise which was removed in the decoding process, as will now be described.

Demodulation and error correction decoding may be advantageously performed by a maximum likelihood sequence estimator according to U.S. Patent Application Serial No. 08/305,727 entitled *"Channel-Independent Equalizer Device"* to coinventor Dent, filed September 14, 1994, the disclosure of which is hereby incorporated by reference herein. Referring to Figure 6, a Viterbi sequential maximum likelihood sequence estimator includes a State Memory **65** for storing a number of hypotheses of a received symbol sequence

together with a path metric for each that is representative of cumulative probability. Processing comprises using a transmitter model **60** which may include a model of the propagation channel learned from processing a known bit sequence called a training sequence or syncword. The latter information is embodied in the Reference Vector Arrays in State Memory **65**.

Transmitter model **60** computes an expected signal value corresponding to a new bit hypothesis on the assumption, for each state in turn, that the previous hypotheses are true. The expected signal value is compared with the received signal value in comparator **61** to obtain the difference. The difference is a measure of the error between the hypothesis and the actual received signal sample, which error is only due to radio noise in the case that the hypothesis is correct. The mismatch indication is added to the previous path metric corresponding to the tested hypothesis to obtain a new cumulative mismatch or path metric.

Adder **62** forms the new path metric from a state having a leftmost bit in the Current Hypotheses memory equal to binary '0', while adder **64** forms the new path metric for a corresponding Current Hypothesis which differs only in the leftmost bit position being a binary '1'. Comparator **63** compares the two new path metrics and selects the lower one and all corresponding contents of the associated state memory to become the new contents of a state memory, with a left shift of the leftmost bit (which will be a 0 or a 1 according to which state gave the lower path metric) out of Current Hypotheses and into Already Processed part of the memory. All previous hypotheses are tested with both '0' and '1' as the hypothesis for a new bit and after processing all these hypotheses the number of states left will be the same as before but all path metrics

will have been updated to the lower of two compared metrics and decoding will have advanced by one symbol.

Operation of Figure 6 is described in more detail in the incorporated patent application. A description of how it can be modified to provide a tuning noise indication according to an embodiment of the present invention.

As stated previously, the comparator **61** computes the difference between a hypothesized signal value and an actually received signal value, which difference will be due only to radio noise in the case the hypothesized signal value is true. Instead of discarding this computed difference, an embodiment of the present invention records the differences alongside each data symbol in the Already Processed part of the state memory. When error correction coding produces several transmitted samples per original data bit to be transmitted, transmitter model **60** will likewise produce several signal samples for comparison and comparator **61** will test these plural samples to obtain several differences. These differences are normally combined as a sum of squares to obtain the mismatch indication before being discarded.

According to the embodiment of the invention, the differences are saved in the state memory **65** against each processed bit decision. The saved differences from one state are allowed to overwrite the saved differences of another state when one of two compared hypotheses is selected to survive by the Viterbi process. The final bit decisions made by the Viterbi MLSE processor are those which minimize the sum square differences. Accordingly, the residual errors are likely to be due only to radio noise and not to incorrect bit decisions. The saved differences are therefore equal to the received radio noise and may be output to speech decoder **510**. Speech coder **510** can add the radio noise samples to the audio signal so that the

user will hear an exact representation of the radio noise characteristics varying proportionally with signal-to-noise ratio and not "chopped" by the abrupt threshold of the decoding process.

Digital radiotelephones that employ digitization of speech signals often incorporate error detection codes as well as error correction coding. For example, a Cyclic Redundancy Check (CRC) code is often appended to the most perceptually important bits in a digital speech transmission. When the CRC check fails, the erroneous bits are prevented from causing unwanted acoustic artifacts by various error concealment strategies also known as "deburping". Such deburping can preserve useful speech qualities when the CRC fails as much as 5% of the time. Detection of CRC failure for more than 5% of the time can be used as a trigger to automatically add the audible signal quality indication to the telephone output in order to cause the user to take corrective action.

The embodiment described above illustrates that noise representations arbitrarily close to the true radio noise can be extracted in principle from a demodulation and decoding process, and artificially reintroduced into an audio signal to give a true indication of rising or falling signal quality, independent of the thresholding characteristics of the demodulator.

It may be desirable to provide an audible indication of signal quality that rises or falls in an emphasized way relative to true signal-to-noise ratio. For example, it may be desired that a 1dB reduction on signal-to-noise ratio should be indicated to the user by a 3dB or 6dB rise in artificially added audible indication. This can be achieved by using, in addition to or alternatively to the saved radio noise waveform, the saved path metric from the decoding process. The path metric is proportional to the mean square of the

radio noise and may be used to scale the audible indication according to the square of the radio noise, or indeed according to any power of the radio noise level.

The audible indication thereby scaled can be a prestored audio waveform, if it is desired to reduce the complexity of the demodulation and decoding process. As previously stated, such a waveform may be chosen to be a "displeasing" sound when it is indicative of falling signal quality. Conversely, a "pleasing" waveform such as a major musical chord can be used when it is scaled inversely, i.e. by dividing it with a power of the path metric, so that its intensity increases with rising signal quality. A combination of a displeasing sound that increases with noise level and a pleasing sound that increases with signal level may also be employed, but at least the "pleasing" sound should be audible when the user selects the "audible tuning indication" to be enabled, so that he can prevent it from causing distraction during a voice conversation with otherwise good signal-to-noise ratio.

Alternatively or additionally, the network may send command messages as previously described to controller **130** in order to remotely turn on or off an audible indication to realign the antenna. Such a command may be issued by the network either based on a signal strength measured by the mobile phone and transmitted as a signal strength report to the network, or may be based on a signal strength measured by the network receiver receiving the mobile phone's transmission, or a combination of both.

It can also be desirable to audibly indicate signal quality to a user not presently engaged in conversation, at which time his phone is periodically receiving signal bursts on a calling channel. To save battery power, mobile phones do not receive

continuously in standby mode but wake up only in a so-called sleep-mode slot which is preassigned by the network to each mobile unit. This may only occur at 1 second intervals for example. The network knows when the mobile receiver will be awake and call alerts to that receiver are transmitted only at those times. Sampling the received signal only at one second intervals may be a little too slow to provide the user with a signal quality indication on standby that he can optimize by moving the antenna position. If necessary, the user can be required to enable the audible indication by depressing a button, which, when the phone is in standby mode, can temporarily cause the receiver to operate continuously or at least sufficiently frequently to measure signal strength for the purposes of aligning the antenna.

When not in conversation, there is no disadvantage in providing an audible indication of the "pleasing" variety such as a musical hum that rises in intensity with improving signal quality. Instructions in the equipment user manual can then be abbreviated to "align for maximum hum" which is an easy instruction for the user to follow. Different "hums" can be provided depending on the identity of the network station the phone is locked to, for example a "space hum" when the phone is locked to a landbased cellular system.

In the drawings and specification, there have been disclosed typical preferred embodiments of the invention and, although specific terms are employed, they are used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention being set forth in the following claims.

THAT WHICH IS CLAIMED:

1. A mobile radiotelephone comprising:

a mobile radiotelephone antenna;

means for receiving radiotelephone communications via said mobile radiotelephone antenna;

means, responsive to said receiving means, for converting the received radiotelephone communications into audible radiotelephone communications; and

means, responsive to said receiving means, for injecting an audible alignment signal which is a function of the orientation of the radiotelephone antenna, into the audible radiotelephone communications, to thereby prompt a radiotelephone user to reorient said radiotelephone antenna for improved alignment relative to the received radiotelephone communications.

2. A mobile radiotelephone according to Claim 1 wherein said received radiotelephone communications have a received signal strength which is a function of the location of said radiotelephone antenna, said injecting means comprising means for injecting an audible alignment signal which is a function of the received signal strength of the received radiotelephone communications.

3. A mobile radiotelephone according to Claim 2:

wherein said receiving means comprises abrupt cutoff receiving means, for suppressing the received radiotelephone communications when the received signal strength of the received radiotelephone communications is below a threshold; and

wherein said injecting means comprises means for injecting an audible alignment signal which is a function of the received signal strength of the

radiotelephone communications signal, to indicate that the received signal strength is decreasing to the threshold.

4. A mobile radiotelephone according to Claim 3 wherein said abrupt cutoff receiving means comprises digital coded radiotelephone receiving means.

5. A mobile radiotelephone according to Claim 1 wherein said injecting means comprises means for injecting into the audible radiotelephone communications, artificial noise which changes as a function of the orientation of the radiotelephone antenna.

6. A mobile radiotelephone according to Claim 2 wherein said injecting means comprises means for injecting into the audible radiotelephone communications, artificial noise, the amplitude of which increases in response to decreasing received signal strength of the radiotelephone communications signal.

7. A mobile radiotelephone according to Claim 2 wherein said injecting means comprises means for injecting into the audible radiotelephone communications, periodic artificial noise, the periodicity of which changes in response to decreasing received signal strength of the radiotelephone communications signal.

8. A mobile radiotelephone according to Claim 1 wherein said injecting means is further responsive to a transmit power indicating signal which is received by said receiving means, for injecting an alignment signal which is a function of the orientation

of the radiotelephone antenna and the transmit power of the received radiotelephone communications.

9. A mobile radiotelephone according to Claim 1:

wherein said converting means comprises means for removing noise from the received radio telecommunications; and estimating means for producing an estimate of the noise which is removed from the received radio telecommunications; and

wherein said injecting means comprises means, responsive to said estimating means, for generating an audio indication signal which varies as a function of the estimate; and means for injecting the audio indication signal into the audible radiotelephone communications.

10. A mobile radiotelephone according to Claim 9 wherein said estimating means comprises an error correction decoder including path metric means.

11. A mobile radiotelephone according to Claim 9 wherein said estimating means comprises a Viterbi sequential maximum likelihood sequence estimator.

12. A mobile radiotelephone according to Claim 9 wherein said estimating means comprises:

means, responsive to said receiving means, for computing expected radiotelephone communications;

means, responsive to said computing means, for comparing the expected radiotelephone communications to the received radiotelephone communications to obtain differences between the expected radiotelephone communications and the received radiotelephone communications; and

means, responsive to said comparing means, for generating an error signal based upon the obtained differences.

13. A mobile radiotelephone according to Claim 1 wherein said received radiotelephone communications include a cyclic redundancy check, said injecting means comprising means for injecting an audible alignment signal which is a function of failure of the cyclic redundancy check in the received radiotelephone communications.

14. A mobile radiotelephone according to Claim 1 wherein said injecting means comprises means for injecting an audibly pleasing alignment signal which is a function of increasing received signal strength of the received radiotelephone communications, and for injecting an audibly displeasing signal which is a function of decreasing received signal strength of the received radiotelephone communications.

15. A mobile radiotelephone according to Claim 1 wherein said converting means comprises:

means for removing noise from the received radiotelephone communications;

error detecting means, responsive to said removing means, for detecting that said removing means is unable to remove the noise from the received radiotelephone communications; and

error concealing means, responsive to said error detecting means, for concealing effects of the unremoved noise in the received radiotelephone communications; and

wherein said injecting means is responsive to said error detecting means.

16. A base station for communicating with a mobile radiotelephone in a mobile radio communications system comprising:

variable power transmitting means for transmitting radio communications to the mobile radiotelephone at a power level which varies as a function of the location of the mobile radiotelephone relative to the base station; and

means for causing said variable power transmitting means to transmit to the mobile radiotelephone, an indication of the transmit power level of the radio communications.

17. A base station according to Claim 16 wherein said base station is a terrestrial base station or a satellite base station.

18. A mobile radiotelephone comprising:

means for receiving radiotelephone communications;

signal strength indicating means, responsive to said receiving means, for producing a signal strength indication which is a function of the signal strength of the received radiotelephone communications; and

acoustic transducing means, responsive to said receiving means and to said signal strength indicating means, for producing an audible signal which combines the received radiotelephone communications and said signal strength indication, such that an audible signal strength indication is provided along with audible radiotelephone communications.

19. A mobile radiotelephone according to Claim 18:

wherein said receiving means comprises abrupt cutoff receiving means, for producing an audible

radiotelephone communications signal when received signal strength of the received radiotelephone communications is above a threshold and for suppressing the audible radiotelephone communications signal when the received signal strength is below the threshold; and

wherein said signal strength indicating means comprises means for producing a signal strength indication which is a function of the received signal strength of the radiotelephone communications signal, to indicate that the received signal strength is approaching the threshold.

20. A mobile radiotelephone according to Claim 19 wherein said abrupt cutoff receiving means comprises digital coded radiotelephone receiving means.

21. A mobile radiotelephone according to Claim 19 wherein said signal strength indicating means comprises means for producing artificial noise, the amplitude of which increases as a function of decreasing received signal strength of the radiotelephone communications signal, to indicate that the received signal strength is decreasing towards the threshold.

22. A mobile radiotelephone according to Claim 21 wherein said signal strength indicating means comprises means for producing artificial noise, the amplitude of which increases as a function of decreasing received signal strength of the radiotelephone communications signal, from a received signal strength which is above said threshold to a received signal strength which is below said threshold, to indicate that the received signal strength has decreased beyond the threshold.

23. A mobile radiotelephone according to Claim 19 wherein said signal strength indicating means comprises means for producing periodic artificial noise, the periodicity of which changes as a function of changes in the received signal strength of the radiotelephone communications signal, to indicate that the received signal strength is decreasing towards threshold.

24. A mobile radiotelephone according to Claim 23 wherein said signal strength indicating means comprises means for producing periodic artificial noise, the periodicity of which changes as a function of changes in the received signal strength of the radiotelephone communications signal from a received signal strength which is above said threshold to a received signal strength which is below said threshold, to indicate that the received signal strength has decreased beyond the threshold.

25. A mobile radiotelephone according to Claim 18 wherein said signal strength indicating means is further responsive to a transmit power indicating signal which is received by said receiving means, for producing a signal strength indication which is a function of the signal strength of the received radiotelephone communications and the transmit power of the received radiotelephone communications.

26. A mobile radiotelephone according to Claim 18 wherein said signal strength indicating means comprises:

means for removing noise from the received radio telecommunications; and

estimating means for producing an estimate of the noise which is removed from the received radio telecommunications; and

wherein said signal strength indication is a function of the estimate.

27. A mobile radiotelephone according to Claim 26 wherein said estimating means comprises an error correction decoder including path metric means.

28. A mobile radiotelephone according to Claim 26 wherein said estimating means comprises a Viterbi sequential maximum likelihood sequence estimator.

29. A mobile radiotelephone according to Claim 26 wherein said estimating means comprises:

means, responsive to said receiving means, for computing expected radiotelephone communications;

means, responsive to said computing means, for comparing the expected radiotelephone communications to the received radiotelephone communications to obtain differences between the expected radiotelephone communications and the received radiotelephone communications; and

means, responsive to said comparing means, for generating an error signal based upon the obtained differences.

30. A mobile radiotelephone according to Claim 18 wherein said received radiotelephone communications include a cyclic redundancy check, said signal strength indicating means comprising means for producing a signal strength indication which is a function of failure of the cyclic redundancy check in the received radiotelephone communications.

31. A mobile radiotelephone according to Claim 18 wherein said signal strength indicating means comprises means for producing an audibly pleasing alignment signal which is a function of increasing received signal strength of the received radiotelephone communications, and for producing an audibly displeasing signal which is a function of decreasing received signal strength of the received radiotelephone communications.

32. A mobile radiotelephone according to Claim 18 wherein said signal strength indicating means comprises:

means for removing noise from the received radiotelephone communications;

error detecting means, responsive to said removing means, for detecting that said removing means is unable to remove the noise from the received radiotelephone communications; and

error concealing means, responsive to said error detecting means, for concealing effects of the unremoved noise in the received radiotelephone communications.

33. An antenna alignment indicating method for a mobile radiotelephone which receives radiotelephone communications via a radiotelephone antenna, and which converts the received radiotelephone communications into an audible communications signal, said antenna alignment indicating method comprising the step of:

injecting an audible alignment signal which is a function of the orientation of the radiotelephone antenna, into the audible radiotelephone communications, to thereby prompt a radiotelephone user to reorient said radiotelephone antenna for improved

alignment relative to the received radiotelephone communications.

34. An antenna alignment indicating method according to Claim 33 wherein said received radiotelephone communications have a received signal strength which is a function of the location of said radiotelephone antenna, said injecting step comprising the step of:

injecting into the audible radiotelephone communications, an audible alignment signal which is a function of the received signal strength of the received radiotelephone communications.

35. An antenna alignment indicating method according to Claim 34 wherein said injecting step comprises the step of injecting into the audible radiotelephone communications, artificial noise which changes as a function of the orientation of the radiotelephone antenna.

36. An antenna alignment indicating method according to Claim 34 wherein said injecting step comprises the step of injecting into the audible radiotelephone communications, artificial noise, the amplitude of which increases in response to decreasing received signal strength of the radiotelephone communications signal.

37. An antenna alignment indicating method according to Claim 34 wherein said injecting step comprises the step of injecting into the audible radiotelephone communications, periodic artificial noise, the periodicity of which changes in response to decreasing received signal strength of the radiotelephone communications signal.

38. An antenna alignment indicating method according to Claim 33 wherein said mobile radiotelephone further receives a transmit power indicating signal, and wherein said injecting step comprises the step of:

injecting into the audible radiotelephone communications, an alignment signal which is a function of the orientation of the radiotelephone antenna and the transmit power of the received radiotelephone communications.

39. An antenna alignment indicating method according to Claim 33:

wherein said mobile radiotelephone includes means for removing noise from the received radio telecommunications; and estimating means for producing an estimate of the noise which is removed from the received radio telecommunications; and

wherein said injecting step comprises the step of generating an audio indication signal which varies as a function of the estimate; and injecting the audio indication signal into the audible radiotelephone communications.

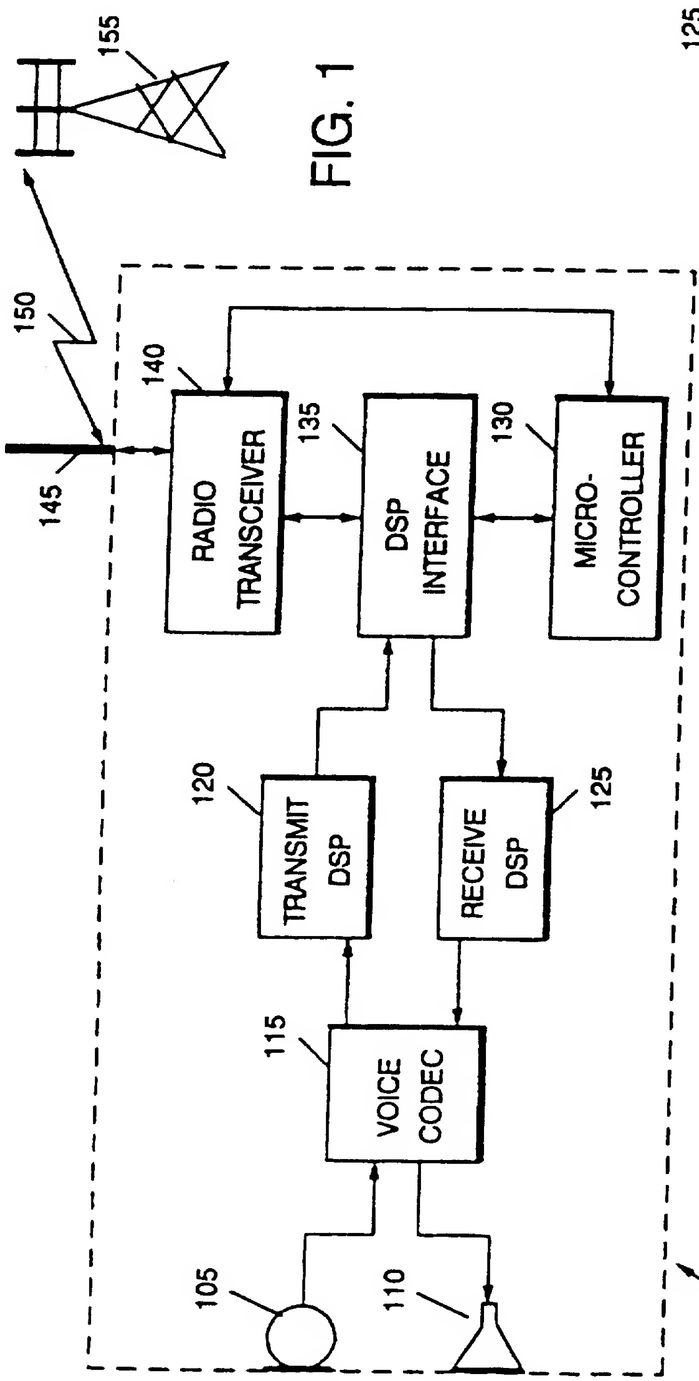
40. An antenna alignment indicating method according to Claim 33 wherein said received radiotelephone communications include a cyclic redundancy check, said injecting step comprising the step of injecting an audible alignment signal which is a function of failure of the cyclic redundancy check in the received radiotelephone communications.

41. An antenna alignment indicating method according to Claim 37 wherein said injecting step comprises the steps of:

injecting an audibly pleasing alignment signal which is a function of increasing received

signal strength of the received radiotelephone communications; and

injecting an audibly displeasing signal which is a function of decreasing received signal strength of the received radiotelephone communications.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MICRO-CONTROLLER
120
TRANSMIT DSP
125
RECEIVE DSP
115
VOICE CODEC
105
110
100

FIG. 1

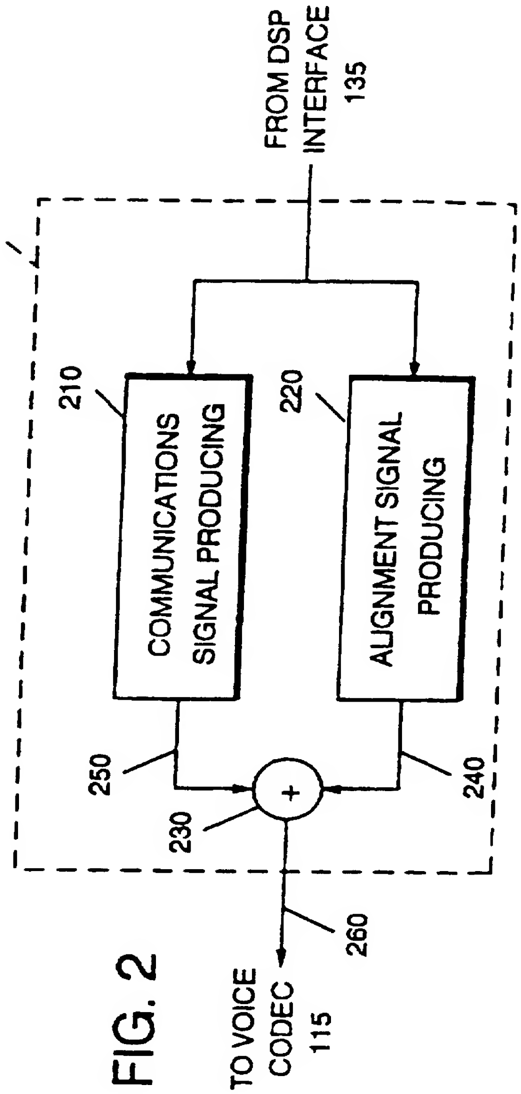
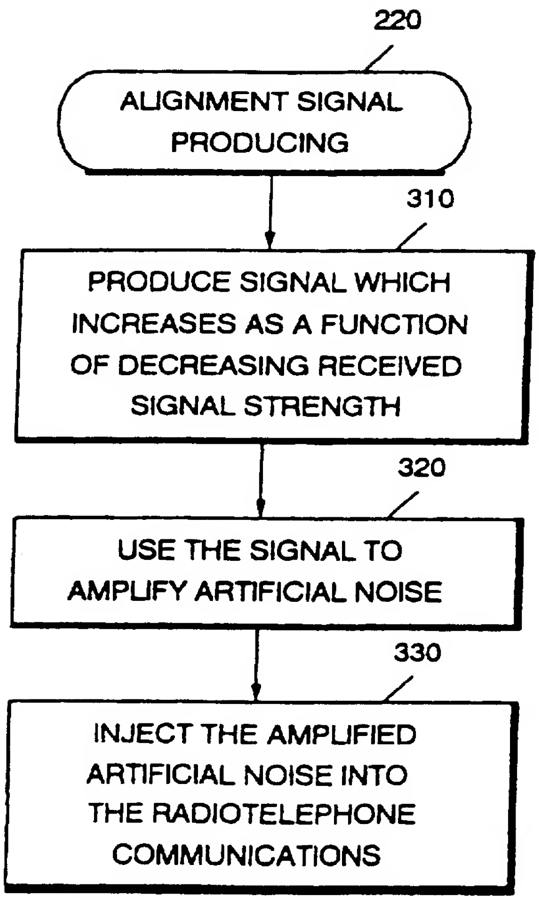

FROM DSP INTERFACE 135
125
210
COMMUNICATIONS SIGNAL PRODUCING
220
ALIGNMENT SIGNAL PRODUCING
250
230
+
240
260
TO VOICE CODEC 115

FIG. 2

FIG. 3


220
ALIGNMENT SIGNAL PRODUCING
310
PRODUCE SIGNAL WHICH INCREASES AS A FUNCTION OF DECREASING RECEIVED SIGNAL STRENGTH
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USE THE SIGNAL TO AMPLIFY ARTIFICIAL NOISE
330
INJECT THE AMPLIFIED ARTIFICIAL NOISE INTO THE RADIOTELEPHONE COMMUNICATIONS

FIG. 4

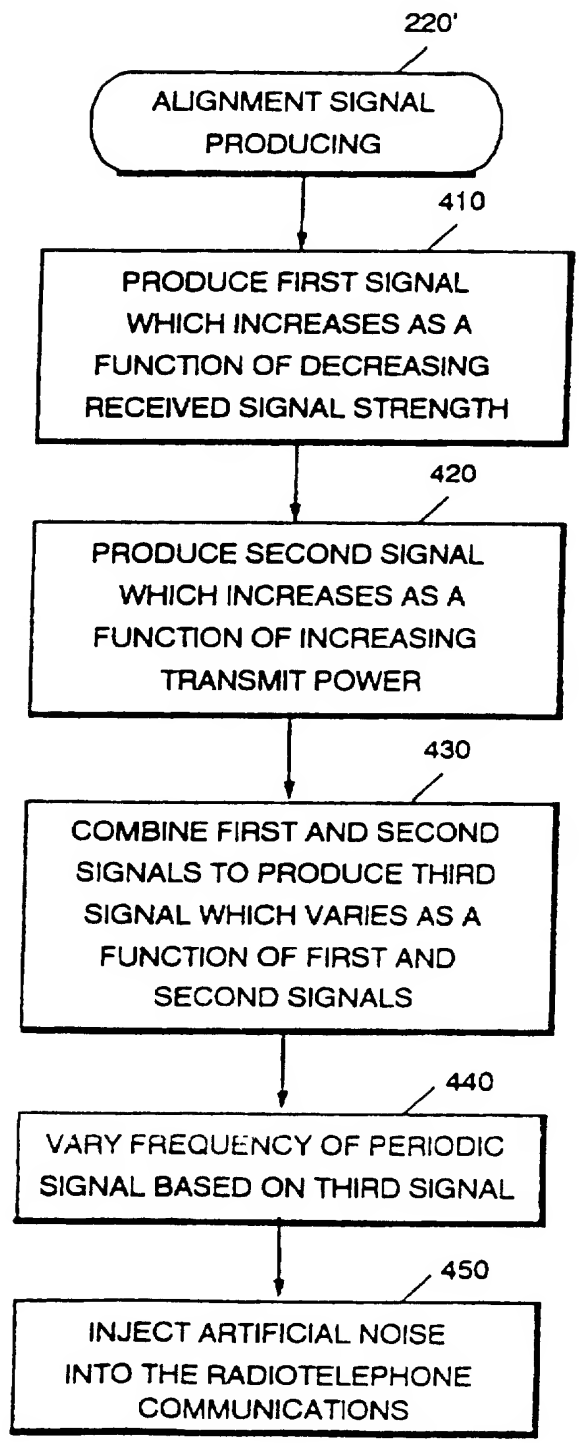
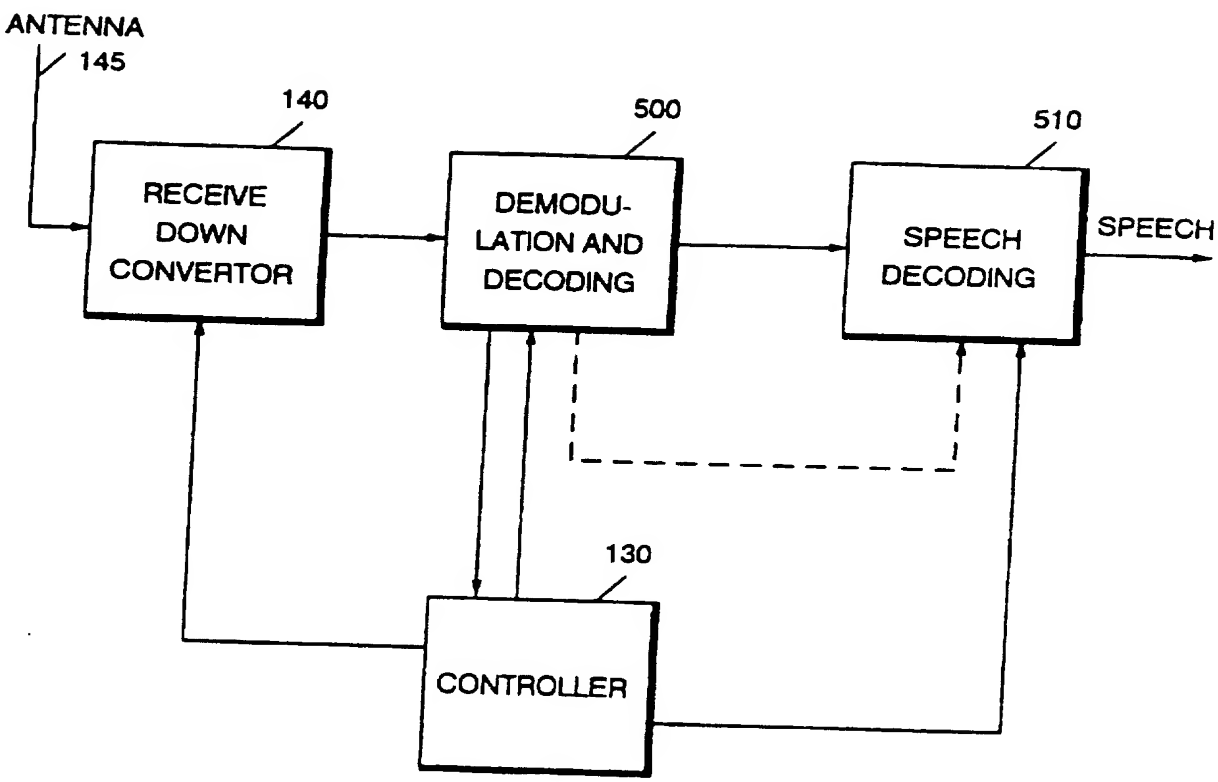

220'
ALIGNMENT SIGNAL PRODUCING
410
PRODUCE FIRST SIGNAL WHICH INCREASES AS A FUNCTION OF DECREASING RECEIVED SIGNAL STRENGTH
420
PRODUCE SECOND SIGNAL WHICH INCREASES AS A FUNCTION OF INCREASING TRANSMIT POWER
430
COMBINE FIRST AND SECOND SIGNALS TO PRODUCE THIRD SIGNAL WHICH VARIES AS A FUNCTION OF FIRST AND SECOND SIGNALS
440
VARY FREQUENCY OF PERIODIC SIGNAL BASED ON THIRD SIGNAL
450
INJECT ARTIFICIAL NOISE INTO THE RADIOTELEPHONE COMMUNICATIONS

FIG. 5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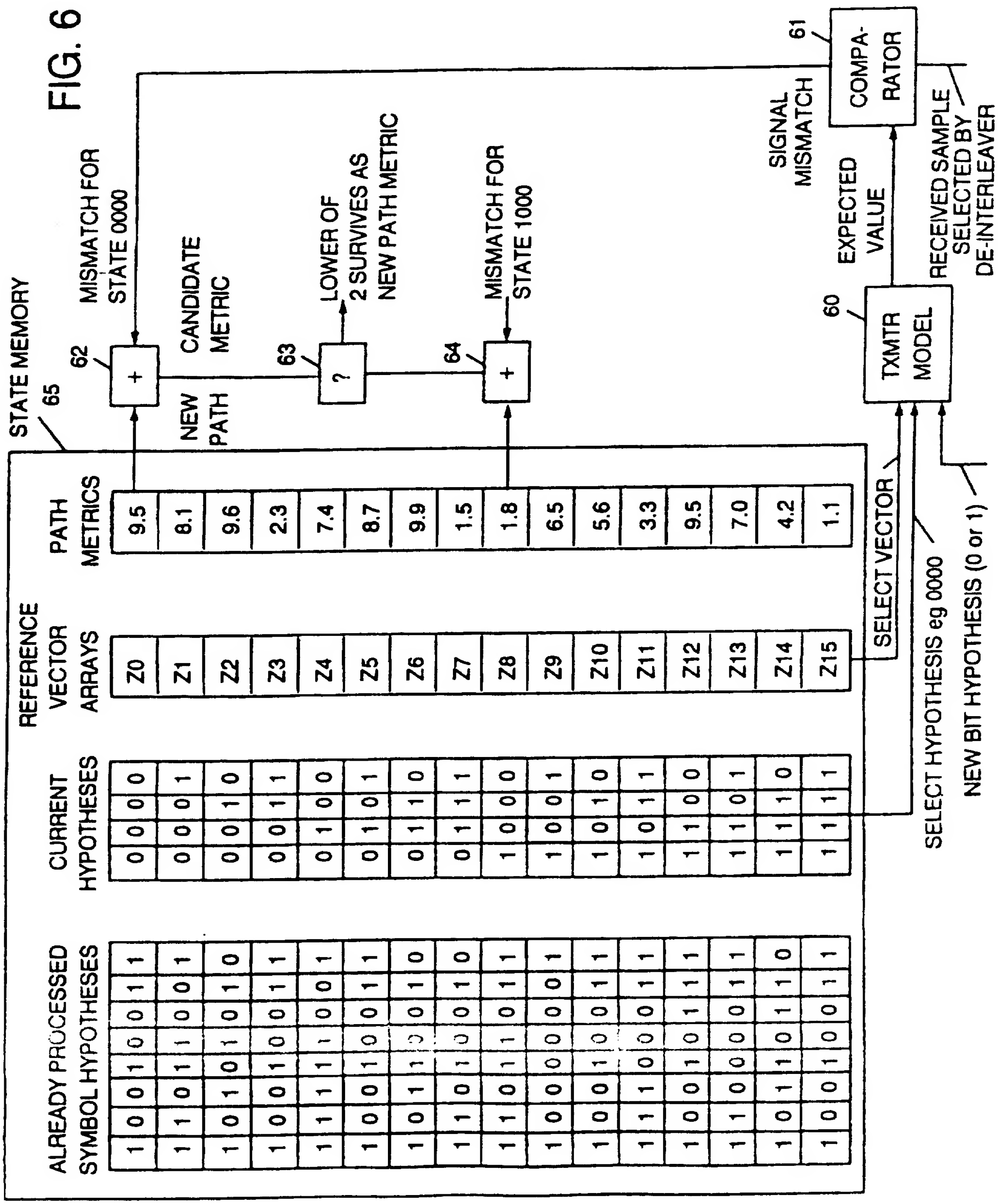
145
140
500
510
RECEIVE
DOWN
CONVERTOR
DEMODU-
LATION AND
DECODING
SPEECH
DECODING
SPEECH
130
CONTROLLER

FIG. 6


STATE MEMORY
65
ALREADY PROCESSED SYMBOL HYPOTHESES
CURRENT HYPOTHESES
REFERENCE VECTOR ARRAYS
PATH METRICS
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Z1
Z2
Z3
Z4
Z5
Z6
Z7
Z8
Z9
Z10
Z11
Z12
Z13
Z14
Z15
9.5
8.1
9.6
2.3
7.4
8.7
9.9
1.5
1.8
6.5
5.6
3.3
9.5
7.0
4.2
1.1
NEW PATH
62
MISMATCH FOR STATE 0000
CANDIDATE METRIC
63
LOWER OF 2 SURVIVES AS NEW PATH METRIC
64
MISMATCH FOR STATE 1000
SIGNAL MISMATCH
61
COMPA-RATOR
EXPECTED VALUE
60
TXMTR MODEL
RECEIVED SAMPLE SELECTED BY DE-INTERLEAVER
SELECT VECTOR
SELECT HYPOTHESIS eg 0000
NEW BIT HYPOTHESIS (0 or 1)